The Hardware Design of Intelligent Sensor and Teds Technology Application

Zhang Huixin, Yang Haiguang, and YangYanjiao

Abstract—**IEEE1451.2 standard stipulated the transmitter Independent Interface (hereinafter referred to as the Transducer Independent Interface TII Interface) and transmitter Electronic Data form (hereinafter referred to as the Transducer Electronic Data Sheet TEDS). Making title sensors as example, this paper design the hardware circuit through the integration way, combine TEDS technology and ordinary sensor, give TEDS technology plan and the implementation process in the system. On the one hand realized the sensor signal digital transmission, on the other hand through the FPGA mark of sensor, and sensor information storage EEPROM, we make the data acquisition system can use this information to mark the sensor for automatic identification, realize standardization in ordinary sensor add function, and make it has certain ego describe ability.**

Index Terms—**FPGA, IEEE1451.2, sensors, TEDS**

I. INTRODUCTION

Smart transducers (sensors/actuators) are gaining increasingly attentions featuring the abilities to sense and process data equipped with microprocessor, providing local "intelligence" and network capability, which is especially true with regard to the aerospace area where transducer devices play an essential role and there is an more rigorous requirement of reliability and precision for the transducer devices[1]. In this paper, we introduce a method of integration signal conditioning circuitry and microcontrollers with digital interface to standardize the traditional sensors and actuators and develop a smart transducer network system [2].

The IEEE1451 standard is aimed to define a set of common interfaces of smart transducers and an architecture for 'smart transducers', allowing integration with any given type of industrial fieldbus protocol on the market to easily support multiple networks and protocols, thus make transducers feature the capability of "plug and play" [3]. Consequently, the IEEE1451 standard should conform to a world-wide standard and facilitate the development of transducer and guarantee the standardization of smart transducer that can be universally accepted by the world [4]. The IEEE1451.1 is a substandard of IEEE1451 standard family, introducing the concept of Network Capable Application Processor (NCAP) that is connected with the Smart Transducer Interface Module (STIM) defined in the substandard IEEE1451.2,by the interface between the STIM

and the NCAP called the Transducer Independent Interface (TII). Moreover, the key novel concept of the IEEE1451 standard is the Transducer Electronic Data Sheet (TEDS), which provides the critical information to describe a transducer in an electronic format, such as manufacturer ID, transducer address, operation range and calibration information etc., adding the capabilities of self-identification and self-calibration to traditional sensors and actuators [5]. In this paper, we describe a approach to intelligentize traditional digital transducers adopting the techniques of TEDS conforming to The IEEE1451 standard.

II. STIM DESIGN AND THE PROPOSED TEDS

A. STIM Design

The proposed STIM hardware is considered to provide the following functionalities: (i)signal conditioning to sensors; (ii)storage for transducers data; (iii)acquisition signals from transducers and communication with high-level architecture via TII interface. The diagram of the improved STIM is presented in Fig.1. The core component of this diagram is the Main Controller. In our case, we use a single-chip called XC2S50, a microprocessor core from the XILINX FPGA (Field-Programmable Gate Array) model family. On the one hand, the Main Controller performs data acquisition from each transducer channel and processing the data; On the other hand, this Main Controller hold the control of the access to the EEPROM memory, where the data is stored. In this way, the information about transducer can be transfered to the high-level fieldbus. The sensor used is this paper is a tilt sensor device ROB100 manufactured by Shaan xi Right M&C Technology Co., Ltd and is based on MEMS(Micro-electromechanical Systems) techniques, measuring pitch angle and roll angle dynamically, providing angle measurement in X-axis with output form of digital signals and performing automatic temperature compensation. The used EEPROM, Atmel's AT26C64 has the memory space of 64K bytes.

In most cases, the signals outputted by the sensors cannot input into microprocessors directly, and these signals need to be properly adjusted before further processing is performed by microprocessors and signal conditioning circuitry with typical functionalities including amplification, level translation, linearization and filtering etc.. Thus they are able to meet the requirements of data formation, amplitude, signal-nosie ratio, sensitivity and precision for microprocessors. In this version of the STIM, a RS-232 is applied to provide the connection between the sensor ROB100 and microprocessors XC2S50.

Data obtained from sensors or employed by the actuators is

stored in EEPROM coded in binary format, and will be sent to and presented on a host PC once there is the read command to require transducer data received by the microprocessors of STIM.
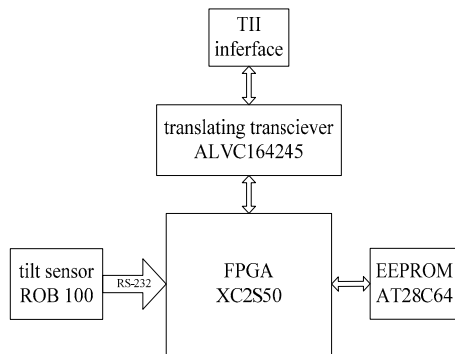

Fig. 1. Hardware architecture of the proposed STIM

B. The Proposed TEDS

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TEDS is intended to intelligentize sensors. However, there is a variety of methodologies to realize the TEDS techniques in consideration of the cost of TEDS and the limit of a certain measurement and control system. At present, there are two kinds of methods to implement the TEDS that are compatible with IEEE 1451.2 [6]. Two proposed methods are:

1) Each TDES is based on hardware, being embedded in STIM and usually stored in on-board memory. Each sensor has its own TEDS contained related parameters needed when operated, which can provided the important characteristics of intelligent. However this kind of TEDS is complex and expensive with regard to update and maintenance.

2) Each TEDS is based software called virtual TEDS. Virtual TEDS file can be defined using database and saved in local computer. The virtual TEDS will be downloaded onto hardware and generated into standard binary TEDS when utilized. This approach allows the system to have a very simple hardware and provides the flexibility to update the information. However, this approach does not achieve truly self-recognition for transducers.

Through the investigation and comparison among exiting realization methods, we find the hardware based TEDS add independence from measuring system to transducers, featuring the characteristic of hot-swap and compatibility. Then virtual TEDS greatly simplify the operate procedure, which can perform parameter setting automatic via software, but fail to achieve the self-recognition of transducers.

Hence, allow for the mentioned issues, we are proposing a innovation approach to develop the TEDS. That is, only a little part of TEDS, the serial transducer ID is store in hardware circuitry and the other information of transducer is saved in virtual TEDS of the host PC. It decreases the load of microcontroller of STIM and facilitates the update and modification of transducer information.

The proposed TEDS is comprised of these three parts: (i)the transducer ID stored in EEPROM memory called on-board TEDS; (ii)the virtual TEDS involved in database system with primary key of transducer ID; (iii)the RS-485 interface between the main microcontroller of STIM and EEPROM memory.

The host PC communicate with low-level hardware via USB(Universal Serial Bus) interface device FT245. Following is the system working procedure: the system starts with the host PC's Initialization work mode for USB, thus the user can sent out commands. The FPGA of STIM checks the TII interface according to set protocols for a soft request. For a data transport request for the transducer ID, the FPGA decodes the function address, which indicates the type of function requested and the channel address, then transfer the ID message to local network by accessing to EEPROM via RS-485 interface; for request for data acquisition, a data acquisition programme will be start up.

The virtual TEDS is formed into tables linked in ACCESS Database in accordance with IEEE1451.2 standard, containing the essential information of the transducers, which can be accessed by the ID. The system processes the acquisition data in diverse ways based on different transducer parameter. The host PC is based on Visual Basic 6.0 to realize monitoring. Fig. 2 illustrates system operation procedure with virtual TEDS parsing algorithm.
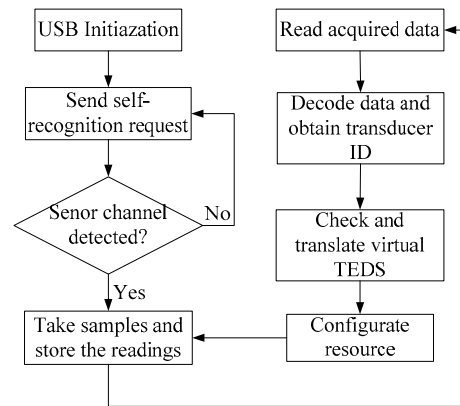

Fig. 2. Operation procedure of the protocol controller.

The monitoring system selects one transducer channel to detect if there is a transducer on line working. If a transducer is on, the system can read its ID and acquisition data, accessing to TEDS stored in EEPROM. By decode the transducer's ID, the host PC can identify the transducer and then access to its virtual TEDS linked to ACCESS Database, thus obtains the functions, usages, and specifications of the transducer, including the communication speed, channel number, data format, signal ranges, physical unit and so on [7]. The virtual TEDS has been developed before being used in accordance with the IEEE 1451.2 and the calibration of the transducer was also done before operation.

III. CONCLUSION

In this case, hardware circuitry designed to intelligentize transducers is introduced according to the proposed, simplified and feasible intelligentization project for transducers, which is fulfilled on the basis of sufficient consideration about IEEE1451.2 standard. Different TEDS realization techniques are integrated to achieve both advantages: self-identification due to hardware based TEDS

and easer update due to virtual TEDS. Main microcontrollers, external memory, field bus techniques, database techniques are implemented to realize smart transducers network, which adds the capacities of self-recognition to transducers by controlling and processing the messages of transducer parameter stored in TEDS, providing flexibility for test system and improving its efficiency. A solution is proposed to standardize traditional transducers and achieve the hot-swap capability and self-calibration, which has a broad promising application prospect in the area of transducer research.

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